

Optimized FFAG Lattices

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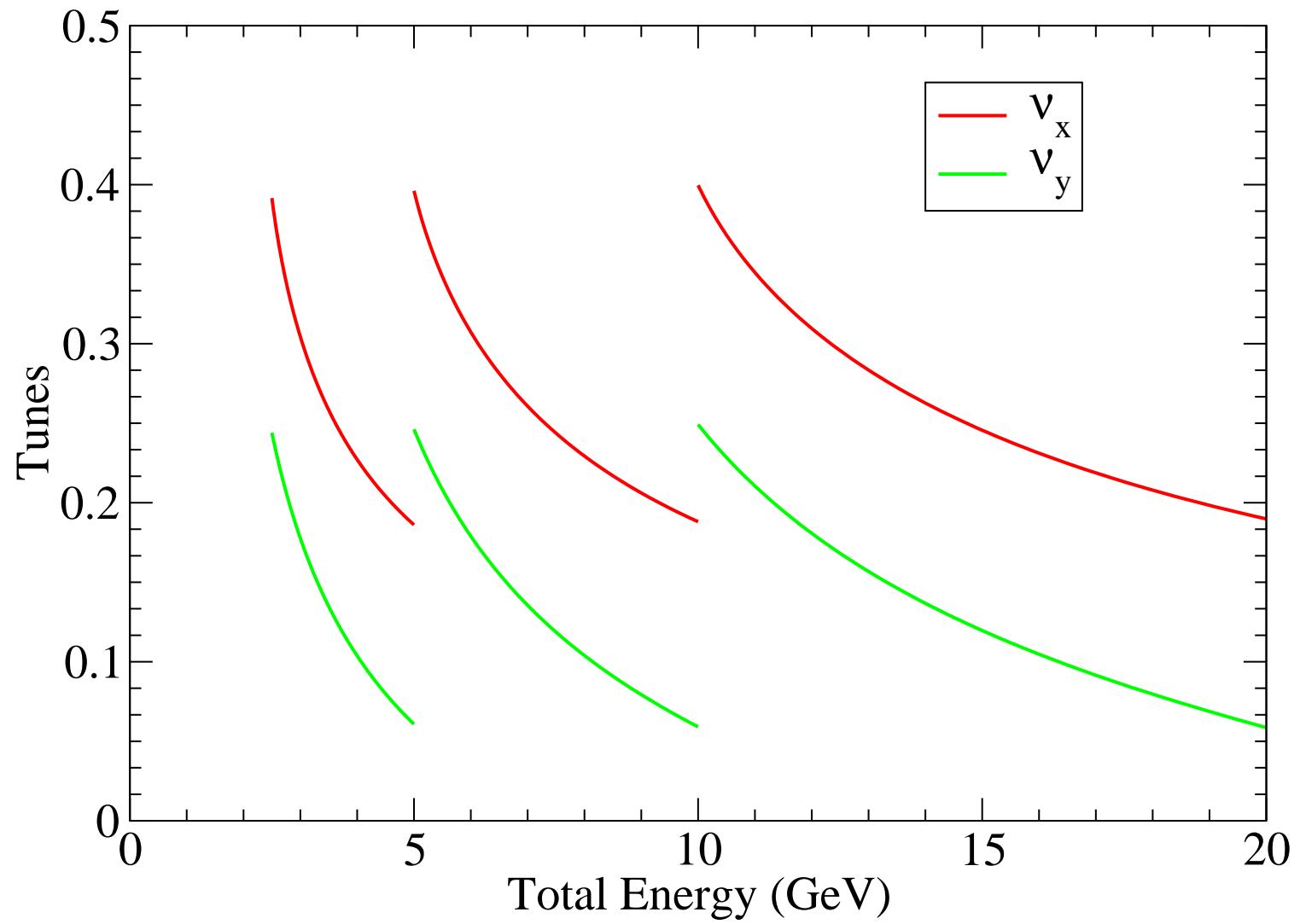
- Find minimum cost lattice, using Palmer's cost formula
- Energy ranges 2.5–5 GeV, 5–10 GeV, 10–20 GeV
- Three lattice types: doublet, triplet, FODO
- Constraints and input parameters
 - ◆ Length for cavity is 2 m
 - ◆ Length between quads is 0.5 m
 - ◆ 201.25 MHz RF, 7.5 MV of RF per cell
 - ◆ Particular choices for $V/\omega\Delta T\Delta E$ for different energy ranges
 - ◆ 30 mm normalized acceptance
 - ◆ 8 cells without RF cavities (injection/extraction)

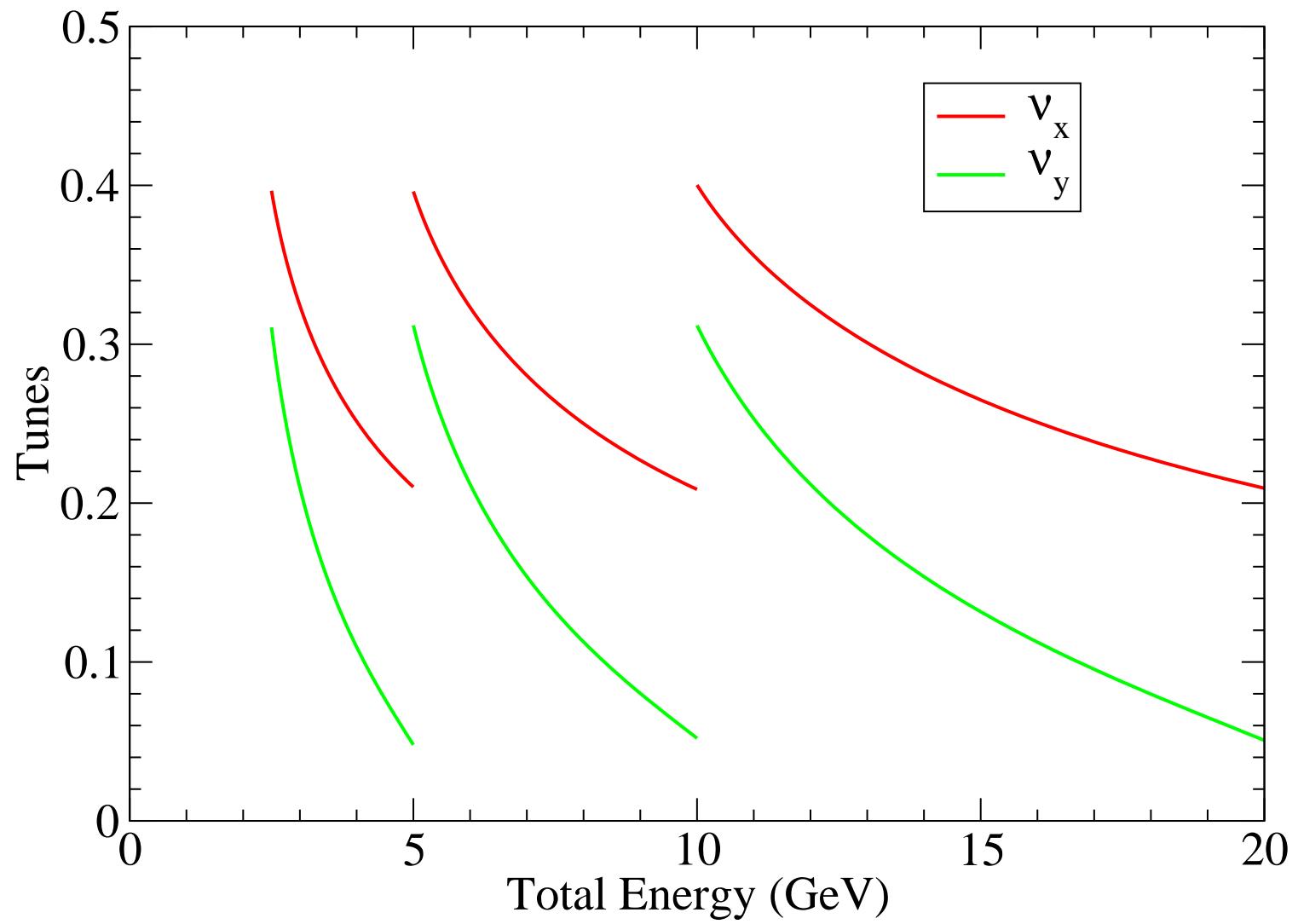
Table of Lattices

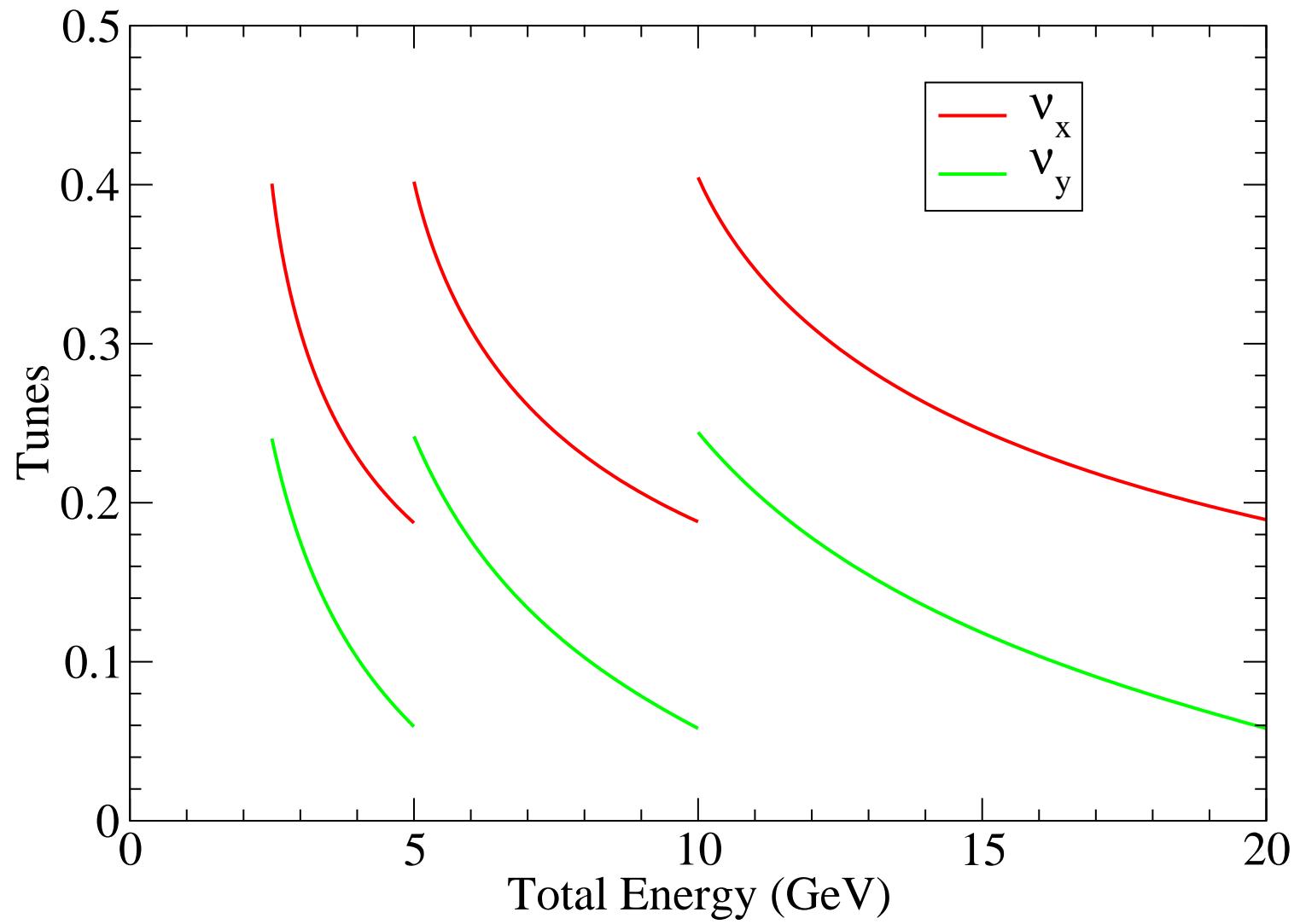
E_{\min} (GeV)	2.5			5			10		
E_{\max} (GeV)	5			10			20		
$V/\omega \Delta T \Delta E$	1/6			1/8			1/12		
Type	FD	FDF	FODO	FD	FDF	FODO	FD	FDF	FODO
No. of cells	73	69	83	86	81	97	100	95	111
D length (cm)	108	158	101	118	168	115	134	188	128
D radius (cm)	15.6	19.6	17.7	11.4	13.6	12.9	8.5	10.3	9.5
D pole tip field (T)	1.9	1.6	1.6	3.0	2.7	2.4	4.3	3.8	3.7
F length (cm)	176	93	172	200	100	198	236	124	228
F radius (cm)	21.8	19.3	25.3	16.9	14.9	19.4	13.8	12.4	15.6
F pole tip field (T)	1.1	1.1	0.9	1.6	1.8	1.3	2.2	2.4	1.8
RF voltage (MV)	488	458	563	585	548	668	690	653	773
$\Delta E/V$	5.1	5.5	4.4	8.5	9.1	7.5	14.5	15.3	12.9
Circumference (m)	390	445	559	489	542	692	620	698	839
Magnet cost (PB)	17	20	17	21	26	21	29	34	27
RF cost (PB)	32	30	36	38	35	43	45	42	50
Linear cost (PB)	10	11	14	12	14	17	16	17	21
Total cost (PB)	58	61	68	72	75	81	89	93	98
Cost per GeV (PB/GeV)	23.4	24.2	27.1	14.3	15.1	16.2	8.9	9.3	9.8

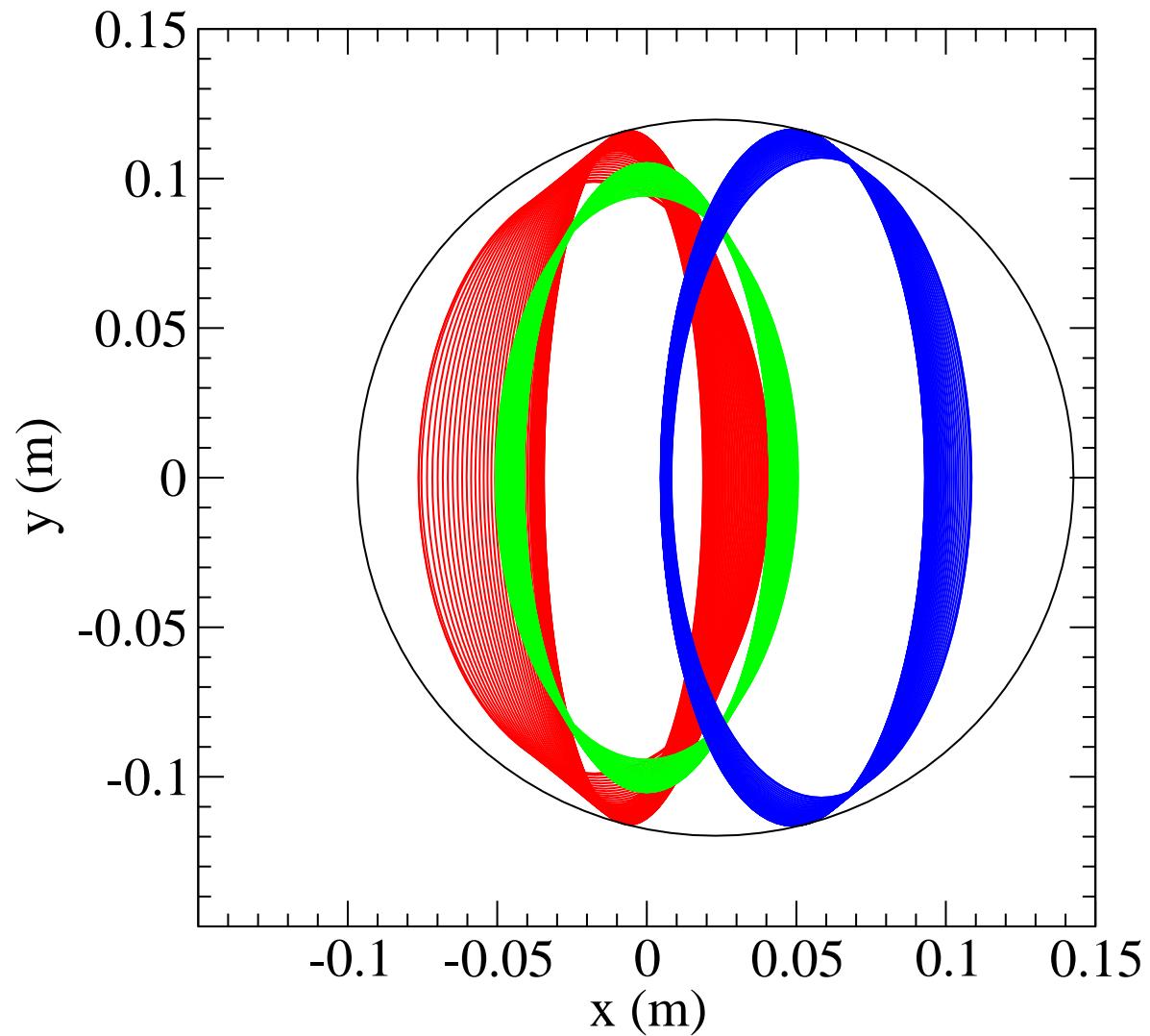
- Doublet wins on cost
 - ◆ Triplet does better on RF, but more magnets
- Lowest energy range is looking interesting
 - ◆ Cost per GeV is looking reasonable
 - ◆ Only a factor of 2 in energy, reasonable $\Delta E/V$
 - ◆ Pole tip fields do not require superconducting!
 - ★ Re-optimize with cost for room temperature magnets
- Rings don't shrink much as energy decreases

- Tunes very different
- Horizontal tune high to reduce time-of-flight range
 - ◆ Not too high: low energy, beta function increases
- Tune profiles independent of energy range
- Reason (vertical): optimum occurs when low and high energy ellipses determine vertical D quad aperture
 - ◆ Lower tune, high energy ellipse will grow
 - ◆ Raise tune, low energy ellipse will grow
 - ◆ Ellipse that grows would increase pipe size
 - ◆ Note required offset of beam pipe
- Lower vertical tunes of doublet help it: less magnet strength
- Similar tradeoff in horizontal









- Make drift spaces depend on magnet parameters (apertures, fields)
- Find better way of choosing $V/\omega\Delta T\Delta E$
- Incorporate third harmonic into cost, try with and without
- Consider other cost models
 - ◆ In particular, room temperature magnets
- Look at dependencies
 - ◆ Cavity voltage
 - ◆ Transverse emittance
 - ◆ Longitudinal emittance